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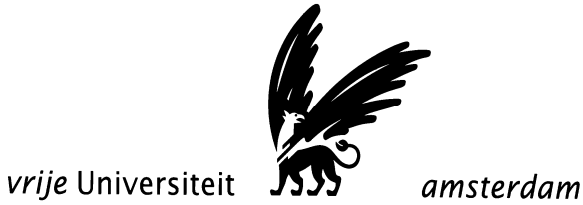

Leniency Programs in the Presence of Judicial Errors

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Abstract

We analyze the effects of antitrust and leniency programs in a repeated oligopoly model outlined in Motta and Polo (2003). We extend their framework by including the possibility of Type I judicial errors and pre-trial settlements. Through comparison of our results to the earlier results we come to a number of novel conclusions. Firstly, antitrust enforcement in the presence of judicial errors is less effective and ex-ante deterrence is weaker than was predicted by Motta and Polo (2003). Secondly, adverse effects of leniency programs are underestimated by the traditional approach, which does not take Type I judicial errors into account.

JEL Classification: K21 Antitrust Law, L41 Horizontal Anti-competitive Practices, C72 Noncooperative Games

Keywords: Collusion, Antitrust, Self-reporting, Judicial Errors, Repeated Game

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1 Introduction

Antitrust policies in the US and the EC currently include leniency programs as one of the key ingredients. Leniency programs grant total or partial immunity from fines to cartel members collaborating with the antitrust authority (AA) by revealing information about the cartel. This revelation may take place *ex-ante* before any investigation by the AA starts, or *ex-post* during an ongoing investigation. Leniency programs are based upon the economic principle that firms, who broke the law, might report their illegal activities if given proper incentives. Effective leniency programs might dissolve existing cartels or, even better, a priori deter such illegal activities.

The US Department of Justice (1998) and Miller (2009) report some empirical evidence in favor of the major modifications of its leniency program in 1993. Despite this evidence, Spagnolo (2007) asserts that the effects of leniency programs are still not fully understood theoretically. Our study belongs to a growing literature on the effects of leniency programs in antitrust. Optimal implementation of antitrust policy and leniency programs for cartel enforcement have been analyzed in e.g. Motta and Polo (2003), Rey (2003), Spagnolo (2008), Harrington (2008), Hinloopen (2003, 2006), Motchenkova (2004), Buccorossi and Spagnolo (2006), Chen and Rey (2007), and Chen and Harrington (2007).

The above mentioned papers offer interesting insights on the effects of leniency programs on the behavior of colluding firms, but they do not consider judicial errors, which is the main ingredient of our paper. Judicial errors and their reduction, i.e. accuracy, are a central concern in law enforcement. They have been analyzed by Kaplow (1994), Kaplow and Shavell (1994, 1996), Polinsky and Shavell (2000), Png (1986), and Tullock (1994) among others. They focus on the negative impact of such errors on marginal deterrence. In this framework accuracy is always desirable, and it is chosen optimally balancing the marginal benefits and costs.

Another stream of literature closely related to this issue is the literature on pre-trial settlements and plea bargaining. There an individual is given the option to plead guilty in exchange for a less harsh penalty rather than waiting for a court decision.[1] Landes (1971) indicates that empirical evidence shows that most cases are disposed of before trial by either a guilty plea or a dismissal of the charges. He shows that the decision to settle or to go to trial depends on the probability of conviction by trial, the severity of the crime, the availability and productivity of the prosecutor's and defendant's resources, trial versus settlement cost and attitudes towards risk. The main result of Landes (1971) is that plea bargaining reduces prosecution cost. Landes neglects the implications of the possible existence of innocent de-

[1] Plea bargaining seems to be comparable to ex-post (after the start of an investigation) leniency application. One difference is that in leniency programs firms can also apply for leniency ex-ante, before an investigation has started. Another difference is that the firm only needs to plea guilty and does not need to provide information about the crime supposedly committed, while in case of applying for leniency in a leniency program firms are obliged to provide evidence.

fendants. Grossman and Katz (1983) do take into account the possibility of having innocent defendants and they use an objective function which incorporates the social disutility of punishing the innocent. They find that plea bargains can act as an insurance device by insuring society against possible erroneous outcomes in a courtroom. We also find a similar result in our paper. The other role it can play is a screening device. This is also implied in Kobayashi and Lott (1996). The above mentioned papers examine a single-defendant setting, but there are also studies on multi-defendant settlements, in which multiple defendants are charged with the same crime and in which they can choose between settling or not. These models fit antitrust cases very well. Examples are Kobayashi (1992), Easaterbrook et al. (1980), and Polinsky and Shavell (1981).

A more specific literature on competition policy enforcement has considered the effects of an inappropriate intervention by an AA. In the model of collusion Schinkel and Tuinstra (2006) find that the incidence of anti-competitive behavior increases in both types of enforcement errors. Type II errors reduce expected fines, while Type I errors encourage industries to collude when faced with the risk of false conviction. This leads to the conclusion that antitrust policy, with non-negligible enforcement errors, can stifle genuine competition. One of the outcomes of our model also confirms this result. In Katsoulakos and Ulph (2009) a welfare analysis of legal standard is developed, comparing per-se rules and discriminating (effect based) rules characterized by a lower probability of errors. The authors identify some key elements that can help to choose the more appropriate legal standard and the cases in which Type I and Type II accuracy is more desirable.

In the literature on enforcement errors and plea bargaining the enforcer balances the goal of condemning the guilty agents and not condemning the innocent ones with the minimization of resources devoted to enforcement. The problem of possibly condemning the innocent ones (a Type I error) plays a vital role in this literature. In competition policy as a whole and leniency programs specifically, the problem of Type I error needs to be taken into account as well. We extend the above mentioned literature by looking at how the impact of leniency programs in antitrust enforcement would change if Type I judicial errors and the possibility of pre-trial settlements and plea bargaining would be present. For this purpose we adopt the repeated games framework outlined in Motta and Polo (2003) and extend it by relaxing a number of assumptions. Motta and Polo (2003) were the first to construct a dynamic analytical framework for analysis of the effects of reduced fines for firms cooperating with the antitrust authorities. They show that, by reducing the expected fines, leniency programs may induce a pro-collusive reaction. So if the recourses available to the AA are sufficient, leniency programs should not be used. However, when the AA has limited resources, leniency programs may be optimal in a second best perspective. Fine reductions when an investigation is opened increase the probability of ex-post desistance and save resources of the AA, thereby raising welfare. They also found that the optimal scheme is to give firms that collaborate, a

full fine reduction and that a regime where firms are entitled to fine discounts even if they reveal information after an inquiry is opened is better than a regime where firms can only get a fine reduction if they reveal before an inquiry is opened.

Our paper extends the model by Motta and Polo (2003) by introducing the possibility of having both Type I and Type II errors and by looking at the behavior of firms when they could be wrongly convicted. We also include the possibility of pre-trial settlements. We analyze an infinitely repeated stage game between firms and the AA in the presence of leniency programs. After the start of an investigation, colluding firms can use a leniency program, reveal information, and pay a reduced fine. Or they can choose not to reveal, which means they will go to trial and pay a full fine if convicted and pay nothing if acquitted. Contrary to Motta and Polo (2003) we have two deviating strategies. If the AA starts an investigation deviating firms can choose not to settle before the court and go to trial, which means they will pay nothing if acquitted and pay a full fine if convicted (Type I error). Or they can choose to make a settlement with the prosecutor by falsely pleading guilty. If they choose to make a settlement they pay a negotiated sentence, which depends on the bargaining power of the firm versus the bargaining power of the AA. The higher the relative bargaining power of the firm the lower will be the expected negotiated sentence. This negotiated sentence is assumed to be lower than the full fine but higher than the reduced fine paid by colluding firms that reveal information.[2] Deviating firms can't apply for a leniency program since they can't provide evidence which proofs the existence of a cartel, so they can only choose between pleading guilty and pleading not guilty.

We find that for certain parameter values innocent firms, knowing they could be convicted, choose to make a settlement with the prosecutor by falsely pleading guilty in order to avoid a possible higher fine. Hence, innocent firms may use pre-trial settlements as an insurance device against possible Type I errors. Another finding is that, when the possibility of Type I errors and pre-trial settlements is not taken into account the adverse effects of leniency programs may be underestimated. What is also found is that, compared to Motta and Polo (2003) model, collusive equilibria become sustainable for a wider range of parameter values. This means that the existence of Type I errors and the possibility to plead guilty may make competition policy less effective. This could be due to the fact that firms choose to use collusion as a precautionary measure against a possible Type I error. This point is also indicated by Schinkel and Tuinstra (2006).

The next section provides the model description. Section 3 looks at firms' decisions. Section 4 gives an overview of the results. Section 5 concludes.

[2] I.e. we assume that colluding firms prefer self-reporting and paying the reduced fine over pleading guilty and paying the negotiated sentence.

2 The Model

We analyze a group of perfectly symmetric firms. These firms choose between collusion or competitive behavior, taking into account the enforcement activity of the antitrust authority (AA). In the equilibrium analysis symmetric firms are considered: hence, all firms will choose the same (collusive or deviating) strategy. The AA and courts are benevolent, but they may commit errors. Following the literature, we can distinguish two types of errors: the enforcer can erroneously fine the firm when it behaves competitively (Type I error) or mistakenly acquit the colluding firm (Type II error). The AA chooses a certain enforcement policy, which might entail the use of leniency programs. The content of the collusive agreement prescribes both the market conduct and the behavior towards the AA. A cartel, for example, may prescribe to its members to replicate the monopoly configuration and to refuse any cooperation with the AA during the inquiries, or conversely, it may allow the members to reveal information if the AA opens a review of the industry. Any firm, if monitored, can choose between either settling before the court or going into trial. If pre-trial settlement occurs, the firm pays a negotiated sentence.[3]

Now, first, the policy choices of the AA are described, moving then to the firms' strategies.

2.1 Enforcement choices

At $t = 0$ the AA sets the following four policy parameters.

- The full fines $F \in [0, \overline{F}]$ for firms that are convicted and have not cooperated with the AA or did not settle before the court, where $\overline{F}$ is exogenously given by the law.
- The reduced fines $R \in [0, \overline{F}]$ specified by a leniency program together with the eligibility conditions. All the firms that cooperate, even after an investigation is opened, can be granted reduced fines R.
- The probability $\alpha \in [0, 1]$ that the firms are reviewed by the AA. This review stage is the first stage of an investigation.
- The probability $p \in [0, 1]$ that the AA successfully concludes the investigation when firms do not cooperate or do not settle before the court.

When the AA is running an investigation it is able to collect and use evidence up to the current period. Once the investigation is opened, the AA has to conclude it with a decision. Extending the Motta and Polo (2003) framework we assume here that the AA can make both Type I and Type II judicial errors: if an industry where firms are not colluding is reviewed, the investigation still enters the prosecution stage. A review on colluding firms can be ended in two ways: either some cartel member reveals information to the AA, in which case the participants are found guilty with probability one (and there is no need to

[3] The size of this sentence is not endogenous in our model but it can be based on the bargaining power of the firm versus the bargaining power of the antitrust authority. The higher the relative bargaining power of the firm the lower will the expected negotiated sentence be.

enter the prosecution stage), or nobody reveals information. In this case the AA has to go on with the investigation, trying to prove the firms guilty, which occurs with probability p (Type II errors might occur) and takes more time.[4] A review of non-colluding firms can be ended in two ways as well: either the firm settles before trial (for example, by making use of plea bargaining) with negotiated sentence, $N \in (R, F)$, smaller than full fine F (and there is no need to enter the prosecution stage), or before court settlement does not succeed. In this case the AA has to go on with the investigation. Then with probability p type I error occurs and the innocent firm has to pay the full fine, and with probability $(1-p)$ the true state of the world (no collusion) is discovered. [5]

The policy parameters are exogenous and once these are set the firms choose their strategies.

2.2 Firms' strategies

After the AA sets the policy parameters at $t = 0$, firms select a collusive strategy or a deviating strategy at $t = 1$. They can choose between one of the following two collusive or one of the following two deviating strategies.

- In the first collusive strategy, CR (Collude and Reveal), firms collude from $t = 1$ on, as long as no deviation occurs. If in period t no inquiry is opened, they realize collusive profits π_M at the end of the period. If in period t the AA opens a review, firms reveal information, pay the reduced fine R and are forced to non-cooperative pricing for the current period, with competitive profits $\pi_N < \pi_M$. In $t+1$, since no deviation from the equilibrium strategy occurred, they go back to the collusive strategy.

- In the second collusive strategy, CNR (Collude and Not Reveal), firms collude from $t = 1$ on, as long as no deviation occurs. If in period t no inquiry is opened, they realize collusive profits π_M at the end of the period. If in period t a review is opened, they do not reveal any information to the AA (which needs therefore another period to conclude the investigation) and obtain collusive profits π_M. At $t+1$, if they are proved guilty, they pay the fine F and set competitive prices, with competitive profits π_N; at $t+2$ they return back to the collusive behavior.[6] If at $t+1$ they are not proved guilty, they obtain collusive profits

[4] When the antitrust authority proves firms guilty, it is able to impose compliance in the current period, for instance by imposing restrictions and remedies on firms' behavior, e.g. competitive pricing. This temporary desistance effect of an adverse decision wants to capture the common fact that a guilty firm is often required to produce reports to the antitrust authority for a certain period on its market strategies and is subject to a light monitoring regime in that phase.

[5] The size of the negotiated sentence $N \in (R, F)$ depends on the bargaining power of the AA versus the bargaining power of the firm. Hence, the negotiated sentence N is not a policy parameter set by the AA. The negotiated sentence N is assumed to be higher than the reduced fine R, since in order to be granted a reduced fine R firms need to provide information which proves the existence of a cartel. This means leniency programs, in which firms pay the reduced fine dominate settlements, in which firms pay the negotiated sentence. Hence, colluding firms would prefer filing a leniency application over plea bargaining. Deviating firms can't apply for leniency since they don't have information which proves the existence of a cartel.

[6] Similar assumption was adopted in Motta and Polo (2003).

π_M and will go on colluding.

- In the first deviating strategy, which is called DPG (Deviate and Plead Guilty), a firm deviates from a collusive agreement at $t = 1$ and in period t the firm realizes a deviating profit π_D (note $\pi_D > \pi_M > \pi_N$) at the end of the period. If in period t the AA opens a review, the firm will plead guilty and pay the negotiated sentence N. From $t + 1$ on, since deviation occurred there will be Nash punishment forever with competitive profits π_N and if an inquiry is opened the firm will plead guilty, settle, and pay the negotiated sentence N.

- In the second deviating strategy, which is called DPNG (Deviate and Plead Not guilty), a firm deviates from a collusive agreement in $t = 1$ and realizes deviating profit π_D in period t and competitive profits π_N in all subsequent periods because of Nash punishment by the other firms. If in period t an investigation is opened, the firm pleads not guilty (pre-trial settlement does not occur), which means the AA needs another period to conclude the investigation. In $t + 1$, if the firm is proved guilty, it pays the fine F and it will receive competitive profit π_N. Starting at $t + 2$ this two stage game is repeated again, with the difference that the first stage profit is given by competitive profit π_N and not deviating profit π_D.

3 The firms' decisions

Before we discuss the set-up outlined above we would like to relate our analysis to Motta and Polo (2003). For comparison, their paper provides analysis of the two collusive strategies: CR and CNR and one Deviating (D) strategy. This leads to three possible equilibrium outcomes, which are: the Collude and Reveal (CR) equilibrium, in which firms choose to collude and reveal if monitored, the Collude and Not Reveal (CNR) equilibrium, in which firms choose to collude and not reveal if monitored and the No Collusion (NC) equilibrium, in which firms choose deviation from a collusive agreement.

In our model, which includes judicial errors (both Type I and Type II) and pre-trial settlement, the simple Deviating strategy is replaced by the two other possibilities. Hence, the set of possible deviating equilibria will expand to the Deviate and Plead Guilty (DPG) and the Deviate and Plead Not Guilty (DPNG) equilibria, in which a firm deviates and, if monitored, respectively pleads guilty or not guilty.

3.1 Collusive strategies

3.1.1 CR: Collude and Reveal

When the collude and reveal strategy is chosen, firms collude in the market and reveal information to the AA if a review is opened. The firms are reviewed with probability α and, if monitored, they reveal and are forced to compete in the current period and pay the reduced fine R; then, the game restarts. Following Motta and Polo (2003) the value of the

collude and reveal strategy (V_{CR}) is given by

$$V_{CR} = \alpha(\pi_N - R) + (1-\alpha)(\pi_M) + \delta V_{CR} = \frac{\pi_M}{1-\delta} - \alpha\frac{\pi_M - \pi_N + R}{1-\delta}. \quad (1)$$

Where π_M are the profits from collusion, $\pi_N < \pi_M$ the non-cooperative profits obtained during the compliance phase and $\delta \in (0, 1)$ is the discount factor. The first term corresponds to the value of collusion in the standard case where no antitrust intervention is considered. The value of collusion becomes smaller if there is antitrust investigation, which happens with probability α, due to two reasons: the firms pay the reduced fine R when found guilty, and they have a profit loss $\pi_M - \pi_N$ when the AA forces them to interrupt the collusive behavior for the current period.

Next, we recall the condition, which is required for the existence of a CR equilibrium in Motta and Polo (2003) under assumption that the AA does not make Type I errors. For that Motta and Polo (2003) compare the value of the CR strategy (V_{CR}) with the value of the simple Deviating strategy (V_D): $V_D = \pi_D + \delta\frac{\pi_N}{1-\delta}$. The inequality $V_{CR} > V_D$ implies

$$\alpha < \alpha_{CR} = \frac{\pi^M - (1-\delta)\pi^D - \delta\pi^N}{\pi^M - \pi^N + R}. \quad (2)$$

If this inequality holds, the CR strategy is preferred over the simple Deviating strategy.

3.1.2 CNR: Collude and not reveal

When the CNR strategy is chosen firms do not reveal if they are monitored, which happens with probability α. This means they continue colluding in the current period, while in the next period they are condemned with probability p; in this case, they pay the full fine F and behave non-cooperatively for the current period, while if not proved guilty collusion continues; after two periods the game restarts. If firms are not monitored in a CNR equilibrium, some other industry will be reviewed and the AA will not open new reviews for two periods, having to conclude the cases opened; hence, firms will have two periods of safe collusive profits before the game restarts. The value of the game under a CNR strategy is therefore

$$V_{CNR} = \alpha\{\pi_M + \delta[p(\pi_N - F) + (1-p)\pi_M]\} + (1-\alpha)(1+\delta)\pi_M + \delta^2 V_{CNR}.$$

After rearranging the following value function is obtained:

$$V_{CNR} = \frac{\pi_M}{1-\delta} - \alpha p\frac{\delta(\pi_M - \pi_N + F)}{1-\delta^2}. \quad (3)$$

The standard cartel profits are reduced by the expected losses from antitrust enforcement, where now the ex-ante probability of being fined is αp.

Next, we find the condition, which is needed for the existence of a CNR equilibrium. Similarly to Motta and Polo (2003), we compare the value of the CNR strategy (V_{CNR}) with the value of the simple Deviating strategy (V_D). The inequality $V_{CNR} > V_D$ implies

$$\alpha < \alpha_{CNR}(p) = \frac{(1+\delta)(\pi_M - (1-\delta)\pi_D - \delta\pi_N)}{p\delta(\pi_M - \pi_N + F)}. \quad (4)$$

Next, we determine when one of the collusive strategies dominates the other. For this purpose the value functions of the two collusive strategies (V_{CNR} and V_{CR}) need to be compared. The inequality $V_{CNR} > V_{CR}$ leads to the following Lemma:

Lemma 1 *A Collude and Not Reveal (CNR) strategy is preferred over a Collude and Reveal (CR) strategy, if the following inequality holds:*

$$p < p_{CNR} = \frac{(1+\delta)(\pi_M - \pi_N + R)}{\delta(\pi_M - \pi_N + F)}. \tag{5}$$

This condition states that if probability of conviction is high enough firms will have higher incentives to self-report. Not surprisingly, the incentives to self-report are smaller when the reduced fine (R) increases. Similarly to Motta and Polo (2003), this threshold divides the region with collusive equilibria into two regions (the CNR and the CR equilibria).

3.2 Non-collusive strategies

3.2.1 DPG: Deviate and Plead Guilty

If a firm chooses the strategy DPG, it will deviate from a collusive agreement and receive a onetime deviating profit π_D. If an investigation starts, which happens with probability α, the firm will plead guilty, settle before the court, and pay the negotiated sentence, N. In all subsequent periods, there will be Nash punishment and the firm receives competitive profits, π_N. Under this strategy, in the subgame after deviation, if an investigation starts, the firm will always plead guilty and pay the negotiated sentence N. So the value of the DPG strategy (V_{DPG}) is

$$V_{DPG} = \alpha(\pi_D - N) + (1-\alpha)\pi_D + \delta V_{PG}.$$

Where the value of a plead guilty (PG) strategy (V_{PG}) in the subgame after deviation is given by the following formula:

$$V_{PG} = \alpha(\pi_N - N) + (1-\alpha)\pi_N + \delta V_{PG} = \frac{\pi_N}{1-\delta} - \alpha\frac{N}{1-\delta}.$$

Substituting V_{PG} into V_{DPG} and rearranging V_{DPG} we obtain the following value function:

$$V_{DPG} = \pi_D - \alpha N + \delta(\frac{\pi_N}{1-\delta} - \alpha\frac{N}{1-\delta}) = \pi_D + \frac{1}{1-\delta}(\delta\pi_N - \alpha N). \tag{6}$$

Here, the expression is composed of the one-time value of deviating in the current period, the discounted future competitive profits less the discounted costs of paying the negotiated sentence whenever the investigation is open. In order to determine when a DPG strategy is preferred over the collusive strategies, the DPG value function (V_{DPG}) needs to be compared with the collusive value functions (V_{CR} and V_{CNR}).

Lemma 2 *A Deviate and Plead Guilty (DPG) strategy is preferred over a Collude and Reveal (CR) and a Collude and Not Reveal (CNR) strategy, respectively, if the following inequalities hold:*

$$\alpha > \alpha_{DPG/CR} = \frac{\pi_M - (1-\delta)\pi_D - \delta\pi_N}{\pi_M - \pi_N + R - N} \tag{7}$$

$$\alpha > \alpha_{DPG/CNR}(p) = \frac{(1+\delta)(\pi_M - (1-\delta)\pi_D - \delta\pi_N)}{p\delta(\pi_M - \pi_N + F) - (1+\delta)N}. \tag{8}$$

Proof. The conditions follow from the inequalities $V_{DPG} > V_{CR}$ and $V_{DPG} > V_{CNR}$, respectively. ■

These conditions imply that incentives to deviate and plea guilty increase when either the negotiated sentence decreases or fines (both full and reduced) increase. Next, the conditions needed for a Deviate and Plead Not Guilty strategy to be preferred over the collusive strategies will be analyzed.

3.2.2 DPNG: Deviate and Plead Not Guilty

If a firm chooses the strategy DPNG it will receive a onetime deviating profit π_D and all subsequent periods there will be Nash punishment with competitive profits π_N. If an investigation starts, which happens with probability α, the firm chooses to plead not guilty, and the AA needs another period to conclude the investigation. In this period the firm receives competitive profits π_N and can be convicted with probability p (due to Type I error), in which case it has to pay the fine F. After two periods the game restarts. The value of the game if a firm chooses the strategy DPNG will be as follows

$$V_{DPNG} = \alpha\{\pi_D + \delta[p(\pi_N - F) + (1-p)\pi_N]\} + (1-\alpha)(\pi_D + \delta\pi_N) + \delta^2 V_{PNG}.$$

Where the value of a plead not guilty (PNG) strategy (V_{PNG}) in the subgame after deviation is given by the following formula

$$V_{PNG} = \alpha\{\pi_N + \delta[p(\pi_N - F) + (1-p)\pi_N]\} + (1-\alpha)(\pi_N + \delta\pi_N) + \delta^2 V_{PNG} = \frac{\pi_N}{1-\delta} - \alpha p\frac{\delta F}{1-\delta^2}.$$

After substituting V_{PNG} into V_{DPNG} and rearranging the following function is obtained

$$V_{DPNG} = \pi_D + \delta\pi_N - \alpha p\delta F + \delta^2\left(\frac{\pi_N}{1-\delta} - \alpha p\frac{\delta F}{1-\delta^2}\right) = \pi_D + \frac{\delta\pi_N}{1-\delta} - \alpha p\frac{\delta F}{1-\delta^2}. \tag{9}$$

Here, the expression is composed of the one-time value of deviating in the current period, the discounted future competitive profits less the discounted costs of paying the expected fine. In order to determine when a DPNG strategy is preferred over the collusive strategies, the DPNG value function (V_{DPNG}) needs to be compared with the collusive value functions (V_{CR} and V_{CNR}).

Lemma 3 *A Deviate and Plead Not Guilty (DPNG) strategy is preferred over a Collude and Not Reveal (CNR) and a Collude and Reveal (CR) strategy, respectively, if the following inequalities hold:*

$$\alpha > \alpha_{DPNG/CNR}(p) = \frac{(1+\delta)(\pi_M - (1-\delta)\pi_D - \delta\pi_N)}{p\delta(\pi_M - \pi_N)} \tag{10}$$

$$\alpha > \alpha_{DPNG/CR}(p) = \frac{(1+\delta)(\pi_M - (1-\delta)\pi_D - \delta\pi_N)}{(1+\delta)(\pi_M - \pi_N + R) - p\delta F}. \tag{11}$$

Proof. The conditions follow from the inequalities, $V_{DPNG} > V_{CNR}$ and $V_{DPNG} > V_{CR}$, respectively. ■

Condition (10) implies that the choice between DPNG and CNR strategies does not depend on the fining system or the structure of the leniency program. While (11) implies that incentives to deviate and plea not guilty increase when either the reduced fine increases or the expected full fine decreases. Next, the condition needed for one deviating strategy to be preferred over the other will be analyzed.

3.2.3 DPG vs. DPNG

In the subgame after the deviation firms either settle or they plead not guilty and investigation continues. In order to determine when one deviating strategy dominates the other, we compare the value functions of the two deviating strategies (V_{DPNG} and V_{DPG}).

Lemma 4 *In any subgame after deviation a Deviate and Plead Not Guilty (DPNG) strategy dominates a Deviate and Plead Guilty (DPG) strategy if the following inequality holds*

$$p < p_{DPNG} = \frac{(1+\delta)N}{\delta F}. \tag{12}$$

Proof. The condition follows from the inequality $V_{DPNG} > V_{DPG}$. ■

From expression (12) it is clear that a reduction in the expected negotiated sentence will result in higher incentive to plea guilty and lower incentive to plea not guilty. The inequality (12) shows that threshold $p_{DPNG}(N)$ decreases if the negotiated sentence decreases. This means the inequality becomes stricter and there are less incentives to plea not guilty and more incentives to plea guilty. The analysis of Subgame Perfect Equilibria outcomes in this model depends on the size of the negotiated sentence N. In the next section we look at the distribution of equilibrium outcomes for three different levels of the size of the negotiated sentence.

3.3 Determination of Subgame Perfect Equilibria

In the following lemma we derive the condition on N such that Figure 1 holds, i.e. the three thresholds derived above in (7), (10), and (12) intersect in the same point. This level of the

negotiated sentence is denoted by N^* and corresponds to the case of intermediate bargaining power for the firm. It also appears that for $N = N^*$ the p_{CNR} threshold derived in Motta and Polo (2003), recall expression (5), exactly coincides with the p_{DPNG} threshold in (12).

Lemma 5 *Plotting thresholds $a_{DPG/CR}$, $a_{DPNG/CNR}(p)$, and p_{DPNG} in the $(p, \alpha) - diagram$ implies that, when $N = N^* = \frac{F(\pi_M - \pi_N + R)}{\pi_M - \pi_N + F} \in (R, F)$, all three thresholds intersect in the same point (p^*, α^*) with $p^* = p_{DPNG}$ and $\alpha^* = a_{DPG/CR}$.*

Proof. Recall expressions for p_{DPNG} and $a_{DPNG/CNR}(p)$ in (12) and (10), respectively. Substituting p_{DPNG} into $a_{DPNG/CNR}(p)$ gives $a_{DPNG/CNR}(p_{DPNG}) = \frac{\pi_M - (1-\delta)\pi_D - \delta\pi_N}{\frac{N}{F}(\pi_M - \pi_N)}$. Next, setting $a_{DPG/CR}(N)$ in (7) equal to $a_{DPNG/CNR}(p_{DPNG})$ gives: $\frac{\pi_M - (1-\delta)\pi_D - \delta\pi_N}{\pi_M - \pi_N + R - N} = \frac{\pi_M - (1-\delta)\pi_D - \delta\pi_N}{\frac{N}{F}(\pi_M - \pi_N)}$. Solving this for N gives: $N^* = \frac{F(\pi_M - \pi_N + R)}{\pi_M - \pi_N + F} < F$.

Moreover $p_{DPNG}(N^*) = \frac{(1+\delta)(\pi_M - \pi_N + R)}{\delta(\pi_M - \pi_N + F)}$ is precisely equal to p_{CNR} specified in (5).

As mentioned above the negotiated sentence N should always be larger than the reduced fine R, otherwise settling is more attractive for colluding firms than application for leniency. Clearly $\frac{F(\pi_M - \pi_N + R)}{\pi_M - \pi_N + F} > R$. Hence, $N^* > R$ holds. ■

Figure 1 illustrates the result of Lemma 5 in $(p, \alpha) - space$, when $N = N^*$. This figure is constructed for the parameter values: $\pi_D = 2$, $\pi_M = 1$, $\pi_N = 0$, $F = 2$, $N = \frac{2}{3}$ and $R = 0$. These parameters are roughly consistent with the current sentencing guidelines and the rules of the US leniency program.

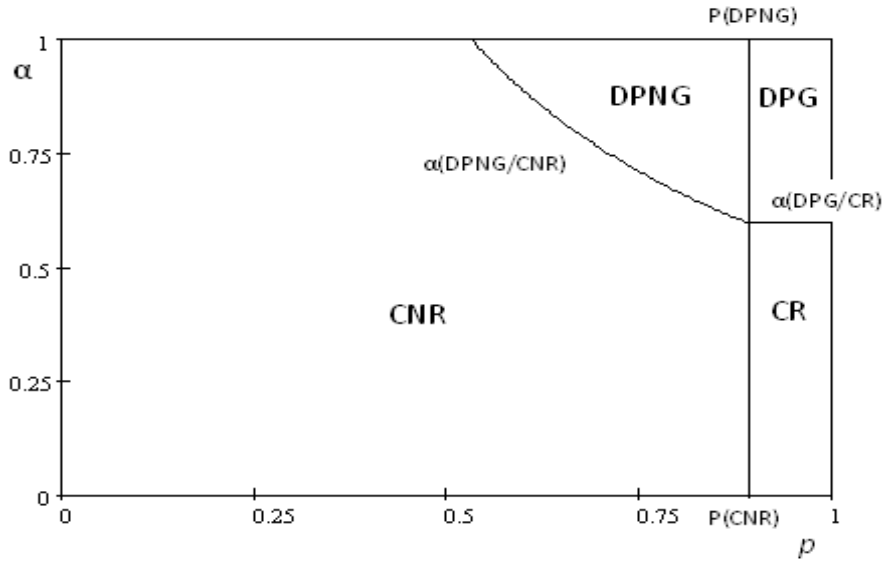

Figure 1. SPE when $N = N^*$

The thresholds $a_{DPNG/CNR}(p)$, $a_{DPG/CR}$, p_{DPNG} and p_{CNR} divide the space in the (α, p) diagram into four regions DPNG, DPG, CNR and CR. These areas indicate for which parameter values it is optimal to choose one of the four strategies. A high probability of being monitored (α) and a high probability of being convicted (p) lead to a Deviate and Plead Guilty (DPG) strategy, while a high probability of being monitored (α) but a bit

lower probability of being convicted (p) lead to a Deviate and Plead Not Guilty (DPNG) strategy. The strategy Collude and Reveal (CR) is chosen when the probability of being monitored (α) is low but the probability of conviction (p) is high. The strategy Collude and Not Reveal (CNR) is chosen when the probability of being monitored (α) is low and the probability of conviction (p) is low.

If the bargaining power of the firm is relatively higher, the expected negotiated sentence N will be lower than N^*. If $N < N^*$, thresholds p_{DPNG} and $a_{DPG/CR}$ given by (12) and (7) shift compared to the $N = N^*$ case and the three thresholds (7), (10), and (12) will not intersect in the same point anymore. In this case the $a_{DPG/CNR}(p)$ threshold will be needed to indicate when a Deviate and Plead Guilty (DPG) strategy is preferred over a Collude and Not Reveal (CNR) strategy. This situation is described in the following lemma and illustrated in Figure 2.

Lemma 6 *When $N < N^*$, plotting relevant thresholds in the (p, α) − diagram implies that the thresholds $a_{DPNG/CNR}(p)$ and $a_{DPG/CNR}(p)$ intersect at p_{DPNG} and the thresholds $a_{DPG/CR}$ and $a_{DPG/CNR}(p)$ intersect at p_{CNR}. This is illustrated in Figure 2.*

Proof. Setting $a_{DPNG/CNR}(p) = a_{DPG/CNR}(p)$ gives:
$\frac{(1+\delta)(\pi_M-(1-\delta)\pi_D-\delta\pi_N)}{p\delta(\pi_M-\pi_N)} = \frac{(1+\delta)(\pi_M-(1-\delta)\pi_D-\delta\pi_N)}{p\delta(\pi_M-\pi_N+F)-(1+\delta)N}$.
Solving this for p gives: $p_{DPNG} = \frac{(1+\delta)N}{\delta F}$.
Setting $a_{DPG/CR} = a_{DPG/CNR}(p)$ gives: $\frac{\pi_M-(1-\delta)\pi_D-\delta\pi_N}{\pi_M-\pi_N+R-N} = \frac{(1+\delta)(\pi_M-(1-\delta)\pi_D-\delta\pi_N)}{p\delta(\pi_M-\pi_N+F)-(1+\delta)N}$. Solving this for p gives: $p = \frac{(1+\delta)(\pi_M-\pi_N+R)}{\delta(\pi_M-\pi_N+F)} = p_{CNR}$. ■

This lemma analyzes the case when a firm has high bargaining power. This is illustrated in Figure 2**,** which is constructed for the parameter values: $\pi_D = 2$, $\pi_M = 1$, $\pi_N = 0$, $F = 2$, $N = 0.6$ and $R = 0$.

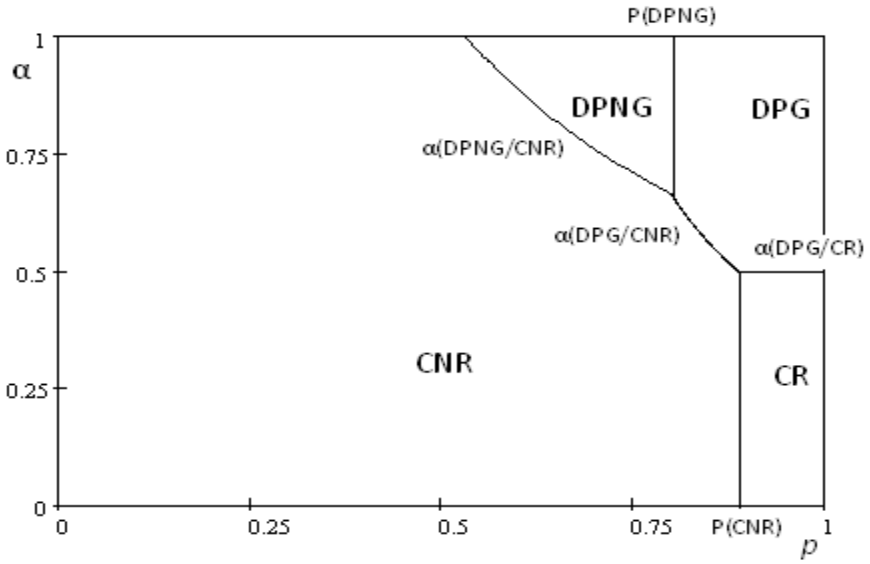

Figure 2. SPE when $N < N^*$

When $N < N^*$, due to a stronger bargaining position and a lower expected negotiated sentence, the DPG area increases. This implies that the Deviate and Plea Guilty strategy has become more attractive and it is sustainable for a bigger range of parameter values. Moreover, the leftward shift of the p_{DPNG} threshold and the downward shift of the $a_{DPG/CR}$ threshold imply that the DPNG, CR and CNR strategies have become less attractive, since they are sustainable for a smaller range of parameter values compared to Figure 1.

If the firm has a relatively lower bargaining power, the expected negotiated sentence N will be higher than N^*. In this case thresholds p_{DPNG} and $a_{DPG/CR}$ given by (12) and (7) also shift compared to the $N = N^*$ case and the three thresholds in (7), (10), and (12) do not intersect in the same point anymore. In this case the $a_{DPNG/CR}(p)$ threshold will be needed to indicate when a Deviate and Plead Not Guilty (DPNG) strategy is preferred over a Collude and Reveal (CR) strategy. This situation is described in the following lemma and illustrated in Figure 3.

Lemma 7 *When $N > N^*$, plotting relevant thresholds in the $(p, \alpha) - diagram$ implies that the thresholds $a_{DPNG/CNR}(p)$ and $a_{DPNG/CR}(p)$ intersect at p_{CNR} and the thresholds $a_{DPG/CR}$ and $a_{DPNG/CR}(p)$ intersect at p_{DPNG}.*

Proof. Setting $a_{DPNG/CNR}(p) = a_{DPNG/CR}(p)$ gives:
$\frac{(1+\delta)(\pi_M-(1-\delta)\pi_D-\delta\pi_N)}{p\delta(\pi_M-\pi_N)} = \frac{(1+\delta)(\pi_M-(1-\delta)\pi_D-\delta\pi_N)}{(1+\delta)(\pi_M-\pi_N+R)-p\delta F}$.
Next, solving for p gives $p_{CNR} = \frac{(1+\delta)(\pi_M-\pi_N+R)}{\delta(\pi_M-\pi_N+F)}$.
Setting $a_{DPG/CR} = a_{DPNG/CR}(p)$ gives: $\frac{(1+\delta)(\pi_M-(1-\delta)\pi_D-\delta\pi_N)}{(1+\delta)(\pi_M-\pi_N+R)-p\delta F} = \frac{\pi_M-(1-\delta)\pi_D-\delta\pi_N}{\pi_M-\pi_N+R-N}$. Next, solving for p gives: $p = \frac{(1+\delta)N}{\delta F} = p_{DPNG}$. ■

This lemma reflects the case of low bargaining power for the firm. Figure 3 illustrates the case of $N > N^*$ and is constructed for the parameter values $\pi_D = 2$, $\pi_M = 1$, $\pi_N = 0$, $F = 2$, $N = 0.72$ and $R = 0$. In this case the relative bargaining power of the firm is lower than in the $N = N^*$ case. Deviating firms have the option to plead guilty and pay the negotiated sentence in order to avoid a Type I error, but since the negotiated sentence is relatively high, the incentives to plea guilty are reduced and as a result the DPG area shrinks and the DPNG and the CR areas expand. The CNR area stays the same. The Deviate and Plead Not Guilty (DPNG) strategy now becomes more attractive. The CR area increases as well since with a low bargaining power there are more incentives to choose the strategy Collude and Reveal and pay the reduced fine R instead of the strategy Deviate and Plead Guilty and pay the relatively higher negotiated sentence. This implies that the adverse effects of leniency programs are stronger, compared to the $N = N^*$ case. As defined in Motta and Polo (2003) the adverse effects of leniency programs are indicated by the region of parameter values, which induce CR under leniency programs, while without reduced fines collusion would not occur. This increase in the adverse effects of leniency programs is clearly present, since part of the region of parameter values which corresponds to DPG equilibrium in the $N = N^*$ case now corresponds to CR equilibrium in the $N > N^*$ case.

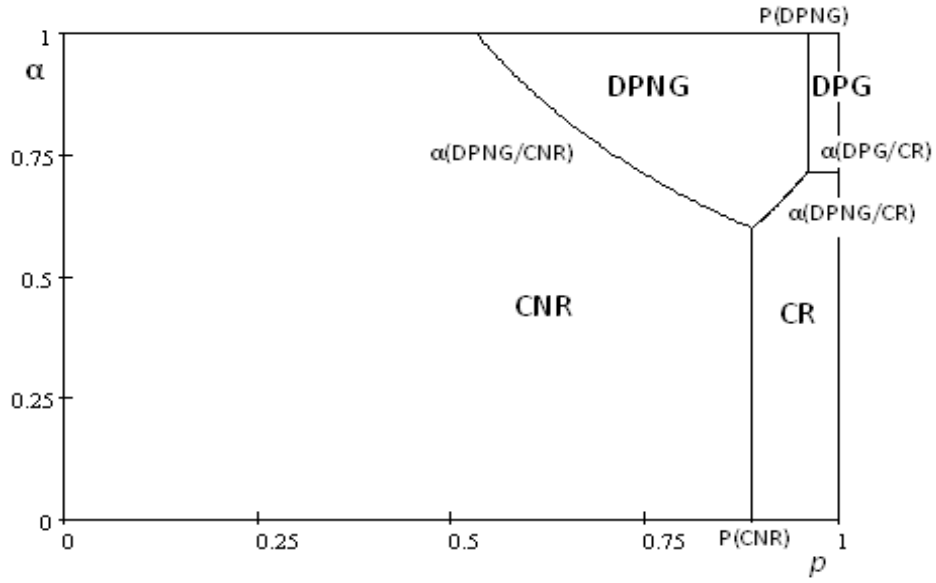

Figure 3. SPE when $N > N^*$

4 Results

Based on the above mentioned thresholds, for three different levels of the negotiated sentence, we can determine for which parameter values the four different Subgame Perfect Equilibria (DPNG, DPG, CNR and CR) are sustainable.

Proposition 8 *In the repeated game played by the firms from $t = 1$ on, once the policy parameters (F, R, α, p) are set, we can describe the Subgame Perfect Equilibria (SPE) in the (α, p) space for three levels of the negotiated sentence (N) as follows:*

- When $N = N^*$, DPG is the Pareto dominant SPE for $\alpha \in (\alpha_{DPG/CR}(N), 1]$ and $p \in (p_{DPNG}(N), 1]$, DPNG is the Pareto dominant SPE when α is above the locus $\alpha_{DPNG/CNR}(p)$ and p is below the locus $p_{DPNG}(N)$, CR is the Pareto dominant SPE for $\alpha \in [0, \alpha_{DPG/CR}(N))$ and $p \in (p_{CNR}, 1]$, while the unique SPE is CNR otherwise.

- When $N < N^*$, DPG is the Pareto dominant SPE for $\alpha > \max\{\alpha_{DPG/CR}(N), \alpha_{DPG/CNR}(p)\}$ and $p > p_{DPNG}(N)$, DPNG is the Pareto dominant SPE when α is above the locus $\alpha_{DPNG/CNR}(p)$ and p is below the locus $p_{DPNG}(N)$, CR is the Pareto dominant SPE for, $\alpha \in [0, \alpha_{DPG/CR}(N))$ and $p \in (p_{CNR}, 1]$, while the unique SPE is CNR otherwise.

- When $N > N^*$, DPG is the Pareto dominant SPE for, $\alpha \in (\alpha_{DPG/CR}(N), 1]$ and $p \in (p_{DPNG}(N), 1]$, DPNG is the Pareto dominant SPE for, $\alpha > \max\{\alpha_{DPNG/CR}(p), \alpha_{DPNG/CNR}(p)\}$ and p is below the locus $p_{DPNG}(N)$, CNR is the Pareto dominant SPE when α is below the locus $\alpha_{DPNG/CNR}(p)$ and $p < p_{CNR}$, while the unique SPE is CR otherwise.

Proof. Follows from Lemmas 1-7 and illustrated by figures 1, 2, and 3. ■

Proposition 8 identifies the regions where the DPNG, DPG, CNR and CR equilibria exist, for three different levels of the negotiated sentence (or bargaining power of the firm).

In case of intermediate bargaining power ($N = N^*$) a high probability of investigation (α) and a high probability of being convicted guilty (p) will lead to a DPG equilibrium and a high probability of investigation (α) but a somewhat lower probability of being convicted guilty (p) will lead to a DPNG equilibrium. This is to be expected since a high probability of investigation, $\alpha > \max\{\alpha_{DPNG/CNR}(p), \alpha_{DPG/CR}(N)\}$, leads to firms choosing a deviating strategy. If the probability of being convicted is high as well ($p > p_{DPNG}(N)$) a deviating firm will choose to plead guilty in order to avoid having to pay a high fine in case of a Type I error. However, if the probability of being convicted is somewhat lower the expected loss in case of a Type I error will also be lower and a deviating firm will choose not to plead guilty.

A low probability of investigation (α) and a low probability of being convicted guilty (p) will lead to a CNR equilibrium and a low probability of investigation (α) but a high probability of being convicted guilty (p) will lead to a CR equilibrium. This follows from the fact that a low probability of investigation, $\alpha < \max\{\alpha_{DPNG/CNR}(p), \alpha_{DPG/CR}(N)\}$, leads to a collusive strategy by firms. If the probability of being convicted (p) is low as well, $p < p_{CNR}(R)$, firms may expect a Type II error and choose not to reveal in the subgame after collusion. If the probability of being convicted is high, $p > p_{CNR}(R)$, firms will choose to reveal in the subgame after collusion, meaning they apply for a leniency program in order to avoid being punished.

If the firm has low bargaining power ($N > N^*$), the curves $\alpha_{DPG/CR}(N)$ and $p_{DPNG}(N)$ will respectively shift up and to the right, making a DPG equilibrium sustainable for a smaller range of parameter values and the DPNG and CR equilibria sustainable for a wider range of parameter values. If the firm has high bargaining power ($N < N^*$) the DPG equilibrium is sustainable for a wider range of parameter values and the DPNG, CNR and CR equilibria are sustainable for a smaller range of parameter values. So the relative bargaining power of the firms influences the conditions needed for the existence of the equilibria. This leads us to the following proposition.

Proposition 9 *For given N, the DPG equilibrium exists when $\alpha > \alpha_{DPG/CR}(N)$ and $p > p_{DPNG}(N)$. When the size of the negotiated sentence (N) decreases, the DPG equilibrium becomes sustainable for a wider range of parameter values.*

Proof. First, consider the situation described in Figure 1, where $N = N^*$. Clearly, the set of parameters, for which the DPG strategy can be sustained as a SPE, is non-empty. Next, recall expressions (7) and (12) for thresholds $\alpha_{DPG/CR}(N) = \frac{\pi_M - (1-\delta)\pi_D - \delta\pi_N}{\pi_M - \pi_N + R - N}$ and $p_{DPNG}(N) = \frac{(1+\delta)N}{\delta F}$. Clearly, when N decreases ($N < N^*$, see also Figure 2), threshold $\alpha_{DPG/CR}(N)$ shifts down and threshold $p_{DPNG}(N)$ shifts to the left. This means the range of parameters, for which the DPG strategy can be sustained as a SPE, expands. ■

This proposition implies that deviating firms may choose to plead guilty in order to avoid being wrongly convicted, and the higher the relative bargaining power, i.e. the lower the

expected negotiated sentence, the more incentive they have to do so. So plea bargaining may be used as an insurance device against possible Type I errors. This confirms the result obtained in different setting in Grossman and Katz (1993).

4.1 Comparison to Motta and Polo (2003)

The following figure compares the situation without Type I errors and pre-trial settlements, as in Motta and Polo (2003), with the case in which Type I errors and pre-trial settlements are included, as discussed in our model. The figure is constructed for the parameter values: $\pi_D = 2$, $\pi_M = 1$, $\pi_N = 0$, $F = 2$, $N = \frac{2}{3}$ and $R = 0$, but, obviously, results of this comparison also hold in general setting whenever $N = N^*$.

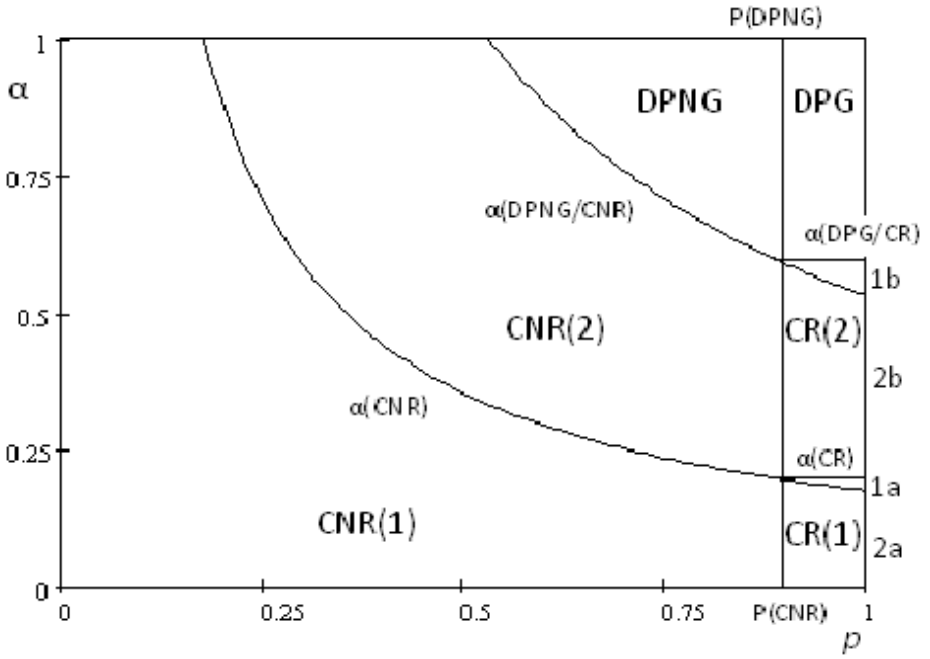

Figure 4. Comparison of results

In the first case, without Type I errors and pre-trial settlements, the regions with collusive equilibria are marked CNR (1) and CR (1) and the rest is the no collusion (NC) region. After including Type I errors and pre-trial settlements the regions with collusive equilibria expand to CNR (2) and CR (2) and the region with the deviating equilibria shrinks and is divided into DPG and DPNG regions. The following proposition can be derived from Figure 4.

Conclusion 10 *The range of parameter values for which collusion can be sustainable expands after including Type I errors and pre-trial settlements.*

Proof. This result follows directly from the fact that the locus $\alpha_{DPNG/CNR}(p)$ in (10) is always above the locus $\alpha_{CNR}(p)$ given by (4). Consider $\frac{(1+\delta)(\pi_M-(1-\delta)\pi_D-\delta\pi_N)}{p\delta(\pi_M-\pi_N)} > \frac{(1+\delta)(\pi_M-(1-\delta)\pi_D-\delta\pi_N)}{p\delta(\pi_M-\pi_N+F)}$. For any $p \in (0,1)$, the numerators of these two expressions are the same, while the denominator of $\alpha_{DPNG/CNR}$ is always smaller than the denominator of α_{CNR},

due to $F > 0$. Next, it is straightforward to show that the locus $\alpha_{DPG/CR}$ in (7) is always above the locus α_{CR} given by (2). ■

This proposition implies that firms are more inclined to choose collusion, when they know there is a possibility that they will be wrongly convicted and they have the option to plead guilty. This means that the existence of Type I errors and the option to settle before trial, may make antitrust enforcement less effective. This could be because firms use collusion as a precautionary measure against a possible Type I error. Similar result was obtained in a different framework by Schinkel and Tuinstra (2006).

Figure 4 also shows that after including Type I errors and possibility of pre-trial settlements, region $1a$ changes to region $1b$ and region $2a$ changes to region $2b$, with region $2a$ being part of region $2b$. As defined in Motta and Polo (2003), region 1 reflects the adverse effects of leniency programs and region 2 reflects the positive effects of leniency programs. Region 1 is a region of parameters, which induces collude and reveal strategy under leniency programs, while without reduced fines collusion would be prevented. Region 2 is a region of parameters for which the use of leniency programs allows to obtain ex-post desistance, by inducing revelation and shortening the investigation. Figure 4 shows that both regions expand compared to results in Motta and Polo (2003). This leads to the following result.

Conclusion 11 *Exclusion of the possibility of Type I errors and pre-trial settlements implies underestimation of the adverse effects of leniency programs.*

Proof. The proof can be visualized by looking at the areas of regions 1a and 1b in Figure 4. Area 1b exceeds the area of region 1a. First we show that the slope of $\alpha_{DPNG/CNR}(p) = \frac{(1+\delta)(\pi_M-(1-\delta)\pi_D-\delta\pi_N)}{p\delta(\pi_M-\pi_N)}$ is always bigger (for the same values of p) than the slope of $\alpha_{CNR}(p) = \frac{(1+\delta)(\pi_M-(1-\delta)\pi_D-\delta\pi_N)}{p\delta(\pi_M-\pi_N+F)}$. Differentiating the above specified thresholds w.r.t. p we obtain $\frac{\partial a_{DPNG/CNR}(p)}{\partial p} = -c\frac{1}{p^2}$ and $\frac{\partial a_{CNR}(p)}{\partial p} = -c'\frac{1}{p^2}$, respectively. Where $c = \frac{(1+\delta)(\pi_M-(1-\delta)\pi_D-\delta\pi_N)}{\delta(\pi_M-\pi_N)}$ and $c' = \frac{(1+\delta)(\pi_M-(1-\delta)\pi_D-\delta\pi_N)}{\delta(\pi_M-\pi_N+F)}$. $c > c'$ hence $\left|-c\frac{1}{p^2}\right| > \left|-c'\frac{1}{p^2}\right|$. This implies that the area of region $1b$ exceeds the area of region $1a$ in Figure 4. ■

This result implies that the traditional approach of looking at the effects of leniency programs, which does not take into account the possibility of Type I errors and pre-trial settlements, may underestimate the adverse effects of leniency programs.

To summarize, incorporation of the important features of real practice like judicial errors and pre-trial settlements in the infinitely repeated game framework suggested in Motta and Polo (2003) gives the following results. Firstly, we find that for certain parameter values innocent firms, knowing they could be convicted, choose to make a settlement with the prosecutor by falsely pleading guilty in order to avoid a possible higher fine. This means innocent firms may use pre-trial settlements as an insurance device against possible Type I errors. Secondly, we conclude that antitrust enforcement in general is less effective than was

predicted by Motta and Polo (2003). When including the possibility of Type I error and plea bargaining, collusive equilibria become sustainable for a wider range of parameter values. This would also imply that the *ex-ante* deterrence is weaker than was estimated in Motta and Polo (2003). Finally, as implied by Conclusion 11, adverse effects of leniency programs are also stronger than was predicted.

5 Conclusion

A lack of information makes competition policy enforcement very difficult and can lead to imperfect competition law enforcement (i.e. Type I errors - convicting innocent firms, or Type II errors - acquitting firms that are in fact guilty). This study is an extension of Motta and Polo (2003) model and looks at leniency programs, pre-trial settlements and enforcement errors. Motta and Polo (2003) constructed a dynamic analytical framework to find out what the effects of leniency programs are. They make the simplifying assumption that if an industry where firms are not colluding is reviewed the investigation does not enter the prosecution stage. Hence, innocent firms will never be prosecuted and therefore will never be convicted. We extend their model by relaxing this assumption and capturing a number of real practice features.

In particular, we include the possibility of prosecuting and convicting innocent firms and the possibility to plead guilty. After the AA starts an investigation into the behavior of firms that deviated from collusion, these firms choose between pleading guilty and pleading not guilty. If a firm pleads not guilty it will be prosecuted and it pays a full fine if convicted and it pays nothing if acquitted. If the firm pleads guilty it will pay a negotiated sentence which is lower than the full fine. As in Motta and Polo (2003) colluding firms can choose between revealing and not revealing. Revealing means they apply for a leniency program and pay a reduced fine. If they do not reveal they will be prosecuted and pay a full fine if convicted and pay nothing if acquitted.

When the model of Motta and Polo (2003) is compared with our extended model, it is found that collusive equilibria become sustainable for a wider range of parameter values. This means that the existence of Type I errors and the possibility of pre-trial settlements may make antitrust enforcement less effective. It is also shown that for certain parameter values a Deviate and Plea Guilty equilibrium is sustainable and that firms that deviated from collusion, choose to plead guilty more often if the negotiated sentence goes down. This means that firms may use a plea bargain as an insurance device against a possible Type I error. Another finding is that the traditional approach of looking at the effects of leniency programs may underestimate the adverse effects of leniency programs.

Our findings lead to the following policy implications. The first best outcome for society would be that firms deviate from collusion and plead not guilty and then get acquitted. The probability of investigation needs to be set at a maximum level in order to achieve deviation.

If the AA doesn't have the resources to investigate all industries and all firms, alternative instruments like increasing fines can be considered. However, the fine and the probability of conviction need to be high enough to achieve deviation but not that high that they lead to innocent firms pleading guilty. Maximum increase in these two policy instruments may lead to the second best outcome, in which firms deviate and plead guilty. If collusion couldn't be prevented the best outcome will be that firms in the subgame after collusion reveal and pay the reduced fine. To achieve this, the reduced fine needs to be minimized, i.e. set equal to zero, which is also advocated in Motta and Polo (2003).

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